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FINAL REPORT
DIGITAL AUDIO
PROJECT
NO: B 85-186

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APPENDIX A

SECTION I:

OBJECTIVES

In 1985 National Library Services for the Blind and Physically Handicapped assigned a three year project to the American Printing House for the Blind and the American Foundation for the Blind to research techniques and applications for digital recording. The project specifically targeted the use of digital recording as a viable and high longevity archival medium. Possible uses for digital as a live recording medium and its usefulness as a production tool were also to be examined. A third leg of the project was to investigate both digital and analogue methods of enhancement and reclamation of older, technically inferior tape and disc recordings.

SECTION II:

ARCHIVAL

A. RESEARCH AND DEVELOPMENT

The initial phase of the project was approached in a fact-finding fashion. Various facilities were visited to research both the equipment used and "the way it's done." Some of the ones visited included: Masterphonics, Custom Mastering, and the Country Music Foundation in Nashville, Tenn.; Digital Audio Discs in Terre Haute, Ind.; Rogers and Hammerstein's, and VOIS Corp. in New York. Throughout the project numerous institutions, companies, and individuals were contacted and were very helpful. Though too numerous to mention here a word of thanks is appropriate.

Following the first months of research formats and methods began to evolve and the first equipment was purchased. Video tape was chosen as the medium over open reel tape. In the video arena VHS was chosen over Beta and 8mm. The reason for this was that VHS was firmly entrenched in the market and Beta and 8mm seemed much less likely to survive as formats. Currently Beta is becoming more and more scarce.

It was decided to record using the LP speed. This would allow using a T-90 video tape to record up to 360 minutes of audio, keeping the tape needed for a book equal to the number of audio cassettes in the book. Since it is not possible to lock out either channel while recording, the track configuration could not match the audio cassette exactly. The video cassette was recorded first with sides one and three. After a brief pause sides two and four were recorded. Sides one and two were recorded on the left channel and three and four on the right channel. See diagram appendix A. In accordance with NLS wishes 16 bit processing was used.

Testing was conducted on five brands of video tape in an attempt to find the most consistent tape (fewest drop-outs) for archival use. The test involved recording on the video tape and counting the number of defects in a given time frame. The counting was done with computer quality verification software. Of the tapes tested BASF and AMPEX ranked highest with Polaroid and Maxell ranking worst. This testing provided a starting point with a quantitative analysis of drop outs. Through actual usage of the higher ranked tapes AMPEX was chosen as the overall best tape for our applications.

As archiving progressed the process was automated by the development, in-house, of an auto start timing network. Also incorporated into the archival procedures was an automated optical scanner and burnisher for the video tapes.

A. RESEARCH AND DEVELOPMENT (cont.)

The RTI model VT-2100 was discovered at an AES show and has become an integral part of the process. The VT-2100 has not only saved time by screening bad video tapes before recording; it has actually reduced the number of tapes with drop outs through its burnishing feature.

B. TYPICAL TRANSFER

The following is a brief description of the archiving process. Equipment hookup diagrams are found in Appendix A. A step by step procedure of the archiving process is contained in Progress Report Number 14 should greater detail be desired.

The video tapes used are first burnished and q. c. ed twice on the RTI model VT-2100. The analogue tapes are mounted on the proper playback machines (Revox PR99s), levels set, and the tapes cued. The video tapes are inserted and cued in the VCRs (Panasonic AG2200s). The auto start is engaged, causing the VCRs to record one minute of silence after which the playback machines engage. Following the end of these first two sides the VCRs run for an additional minute. The next two sides are cued and started in the same manner. The end result is two digital video tape copies each containing the same four successive sides of the archived material. Since the archiving is done at real time but two sides simultaneously, 360 minutes of audio (one video tape) can be recorded in 180 minutes plus approximately 15 minutes of set-up.

After the video tapes are produced they are q. c. ed using an automated setup created in house. A Sony PCM was modified and the output of the error correction circuit sent to a modified remote control unit for an AG2200 VCR. If the PCM detected a fatal error it sent a signal to the VCR via the remote and stopped the tape at the defect. This enabled the q.c. operation to be left largely unattended.

C. PHYSICAL STORAGE CONSIDERATIONS

Since the main purpose of the digital transfer was for long term archival storage several tape manufacturers and users were contacted to gain knowledge on optimum storage conditions. The digital video tape copies, although better protected by the shell than open reel tape, are still subject to damage and deterioration when improperly stored just like other tape media. Research indicated a general consensus

C. PHYSICAL STORAGE CONSIDERATIONS (cont.)

on storage conditions to be a temperature of 40 to 65 degrees Fahrenheit (the cooler the better) and a relative humidity of between 25 and 40 per cent. Under these conditions manufacturers recommend exercising the tape (winding then rewinding) once every five to ten years. If conditions are less than ideal it is recommended the tape be exercised every three to five years. This exercising lessens the stress within a tape pack that develops over long term storage especially if that storage has been under uncontrolled environmental conditions. This stress can cause cinching, other forms of physical damage, and print through. Since digital tape stores audio information as ones and zeros it is not nearly as affected by print through as analogue tape. However, if carelessly stored digital tape will print. Aside from climactic conditions the video cassettes should be stored on edge, not flat, to protect the tape edges and should be stored away from strong magnetic fields.

A final factor in the effort to preserve archived tapes is the playback equipment. Scrupulous maintenance and cleanliness of the playback equipment is a must. It will do no good to have a perfect archived copy of a book and damage it on poorly maintained playback equipment.

D. DATA MANAGEMENT

The last link in the archival chain is a cataloging and retrieval method. A complete catalog of all archived titles has been started in the data base section of a program called "Symphony." Under each entry is the RC number, the title, number of sides, number of video cassettes, the title's bin and shelf location, and who originally transferred the title to digital. A copy is available on floppy disc and a hard copy is located in Appendix A.

The people contacted have all said they have experienced no problems with tape degradation and they have tapes 15 to 20 years old. It is therefore safe to conclude that if stored properly digital tapes have a minimum of 15 to 20 years life and an as yet unknown maximum life span.

SECTION III:
LIVE RECORDING AND PRODUCTION USE

A. DEVELOPMENT AND TITLES PRODUCED

During the course of the project two digital studios were set up at two different times. The first used a JVC model BR-8600 VCR with a JVC model RM-86U remote controller. The last digital studio setup used the same VCR, but through in-house modification & creation of custom controlling circuits it was integrated with the existing studio circuitry. The latter studio had the advantage of using existing talk-back and monitoring capabilities and the studio could be switched from analogue to digital operation quite easily by the monitor.

Between the two studios a total of eight titles were recorded digitally:

- RC24832 Doors to the Universe
- RC24836 Ramona and Her Mother
- RC24837 Ramona the Pest
- RC24958 In a Pig's Eye
- RC25065 Gram Negative
- RC25117 The Pursuit of Holiness
- RC26306 The Forgetful Bears Meet
Mr. Memory
- RC27243 Step by Step

B. PRODUCTION FLOW OF A DIGITALLY RECORDED BOOK

The basic flow of the recording process evolved to the following final form. Blank VCR tapes were striped with time code prior to beginning recording. The tapes were then taken to the studio and the current side of the book read. Next the tapes were proofread and corrections issued by the proofreader. These corrections were carefully timed because all corrections were read on a second VCR tape, not the original studio recording. The proofreader would then proof the corrections and approve them if they were done properly. The approved correction tape and the original reading tapes were taken to the automated editing system for integration into a final corrected copy of the book.

C. BENEFITS AND DRAWBACKS

The reactions to and opinions of the digital recording process from all those involved (technical, nontechnical, and management) was unanimous. All involved could hear a definite improvement in the audio. The signal to noise ratio, frequency response, and dynamic response were all superior to the normal analogue studio recording.

C. BENEFITS AND DRAWBACKS (cont.)

There was also another unanimously expressed opinion; the digital recording process is much slower and more costly than analogue. Even allowing for the definite learning curve involved in the first titles, all of the titles recorded were more time consuming than analogue. An 88 minute analogue master involves approximately seven hours to produce (four hours to record and three hours to proof and correct). On the other hand, an 88 minute digital master involves over twelve and one half hours to produce. This includes ten minutes to set up the tape striping equipment, three and one fourth hours to record, seven hours to proof, one and one half hours for corrections, and forty minutes to set up the automated editing system.

Digital masters take even more time in the following production steps. It currently takes less than 30 minutes to combine four 88 minute studio masters into a four track master for cassette duplication. With digital masters it takes a minimum of 180 minutes to combine four 88 minute masters into one running master for cassette production. Between this increase and the increase in the studio recording time it would cause a one hundred per cent increase in the time spent to obtain a four track running master for cassette production. These two increased costs would result in a minimum increase of 30 cents to the cost of every cassette produced digitally. Added to this is the fact that many of the improvements in the sound track are lost in subsequent production steps (for example, the expanded dynamic range had to be limited or the analogue cassettes tended to have print through). In light of the extra time and expense involved and the absence of the benefits of digital recording in the end product, the pursuit of digital recording in the production of talking books in their current form does not seem feasible or worthwhile.

Where the benefits of digital would truly be felt is if talking books were distributed to the user in digital form. A blind proofer involved in this project very much liked the improvement in quality. While providing books in digital form would not improve the cost of digital recording the benefits would be more readily appreciated by the user. This will be covered more thoroughly in the conclusions section of this report.

SECTION IV:

SONIC ENHANCEMENTS AND RECLAMATION OF OLDER RECORDINGS

A. RESEARCH AND DEVELOPMENT

The third branch of the project dealt with the reclamation and enhancement of older, technically inferior disc and open reel tape recordings. This section of the project would involve the investigation and application of various digital and analogue cleanup methods as well as investigations of physical improvements that might be incorporated in playback (i.e., groove profiles, cleaning, application of lubricants for playback, use of varying playback equipment, etc.) of valued material.

The material provided by the National Library Services was recorded forty or more years ago. This material had a wide range of quality levels. Some recordings exhibited minimal problems while other books had been damaged so extensively that simply getting the information retrieved from the medium was difficult. The types of problems also had a great deal of variety. Groove damage, pops and clicks, poor signal to noise ratio, print through, tape squeal and damage were some of the more common problems encountered.

Again, trips to audio facilities to research the methods and equipment available were the first step. Information was gathered on digital filtering and enhancement. An IBM AT computer and memory expansion was purchased to try in-house digital processing. Two processing programs were purchased, one from Interactive Laboratory Systems and one called Asyst.

B. SOFTWARE SIGNAL PROCESSING -- IN HOUSE

While the processing packages did perform impressively they were very slow and required large amounts of memory. Using fourteen bit resolution and a sample rate of 33kHz, computer data space is used at a rate of 66 kilobytes per second of recorded material. With 16 bit resolution and a sample rate of 44 kHz the computer space needed to process 103 minutes of audio is 510 megabytes. Typical processing times for one minute of audio range from 45 to 60 minutes with some processing times running as high as four hours. Also, because of data storage methods the audio must be processed in six to fifteen minute sections.

A final drawback to the process was the degree of technical skill required to set up and run the programs. While there are now processing programs that do not require as much programming skill there is still the fact that the programs, unlike analogue devices, do not give immediate feedback of the changes made and thus require a greater technical knowledge of audio. This fact, coupled with the amounts of time and computer memory required, would seem to make in-house digital processing of material impractical.

C. SOFTWARE SIGNAL PROCESSING -- OUT-OF-HOUSE

While researching in-house digital processing of signals the use of out-of-house facilities was also investigated. The disc recordings were examined and three recordings were chosen to represent the range of material quality encountered. One disc was in fairly good condition, one was considered of average quality, and the last was chosen to represent some of the poorest quality encountered. Two companies, Micro-Signal and Sonic Solutions, were contacted and furnished with identical copies of the three samples of material.

The results of the processing were a limited success. The recording made from above average quality material showed a good degree of improvement (about 6 db improvement in noise level). However, the sample of the poorest quality material not only showed no improvement, the processing interjected new and strange sounding background noises. Recorded copies of the results were forwarded to NLS.

The use of out-of-house processing does get around the problem of large capital investments in skilled personnel and large capacity computers, but the cost of out-of-house processing is prohibitive. Processing costs are about \$85.00 per minute of recorded material. Sonic Solutions would allow the "rental" of their process for an up front fee plus a monthly fee. With a one year minimum agreement, the fee and the one year's rental would be approximately \$250,000.

D. ANALOGUE SIGNAL PROCESSING

Through visits to production plants and archival institutions a substantial body of information was compiled on current analogue processing equipment as well. It became apparent that the analogue devices were quicker in that they worked at real time playing speeds and they seemed to be easier to operate than digital processing programs. Their only drawbacks were a small sacrifice in the steepness of filter rolloff and a slightly higher noise floor as compared to digital. The effectiveness and comparative simplicity of the analogue equipment together with the drawbacks of digital processing led to the decision to use processing equipment rather than processing software.

Some of the first equipment purchased included a Packburn model 323 noise suppression unit, two Urei model 565-T notch/peak filters, and the basic playback monitoring system. Other signal processors were added later. A DAK model DAK-1 variable frequency noise suppressor, an ART model 1500 digital delay, an Aphex model 103 aural exciter, a DBX model DBXIII range

IV. SONIC ENHANCEMENTS AND RECLAMATION OF OLDER RECORDINGS pg 9 (cont.)

D. ANALOGUE SIGNAL PROCESSING (cont.)

expander, and a Bi-Amp model EQ290 graphic equalizer completed the signal processing rack. A Technics model SP25 turntable was selected for disc playback. All processing equipment was evaluated before purchase either through observation at plants or through experimentation with the equipment on loan. Many pieces had recorded results of use sent to NLS.

E. PHYSICAL PLAYBACK CONSIDERATIONS - DISC

In addition to obtaining the hardware needed to process the recordings the best methods for playback (especially of disc recordings) had to be established. Microscopic examination of groove structures was used to determine groove geometry and areas of damage. Samples were taken from the outer edges of the discs and sent to a lab for chemical analysis in an attempt to determine the best cleaners to use and what cleaners could damage the discs. The test results showed all discs to consist of a basic vinyl compound similar to present day recordings. Scrap discs were taken from production to use as guinea pigs for any cleaning solutions before trying them on valued material. After the initial cleaning solutions were tried it was discovered that while the discs did need cleaning, once cleaned they had pits from ground in debris. A cleaning/lubricating process was thought to be the answer. Through trial and error the cleaning process was refined. The final process consists of suspending the disc over a sonic cleaning bath and rotating the record at a slow rate (0.33 RPM) for between 15 and 20 minutes. The cleaning solution in the sonic bath is an equal mixture of distilled water and Armor All cleaner. The cleaning action is achieved from the sonic bath and the Armor All leaves a residue that lubricates the groove. Following the sonic bath the record is placed on the Nitty Gritty model 1.5 record cleaner. This device rotates the disc over an opening where the excess Armor All is vacuumed from the disc. Improvements of up to six db have been achieved from this process.

From discussions with several archival institutions and microscopic studies of the grooves the decision was made to purchase a range of stylus sizes and choose a stylus for playback based on the specific disc being reclaimed. The idea was not necessarily to match the stylus to the groove exactly but rather to choose a size that would ride on the least damaged portion of the groove while still reproducing the audio in a natural manner. The stylus was chosen by A/B listening comparisons and through the aid of a spectrum analyzer (Audio

E. PHYSICAL PLAYBACK CONSIDERATIONS - DISC (cont.)

Scope model 3113). Some discs' noise levels were reduced as much as six db through careful stylus selection alone.

F. TYPICAL PROCESSING - DISC

A typical record is subjected to a chain of seven steps or blocks of signal processing. First the disc is ultrasonically cleaned in the Armor All solution and dried on the Nitty Gritty machine. Next, with all signal processing equipment bypassed, the best suited stylus is selected using both a subjective listening evaluation and using the Audio Scope model 3113 audio analyzer. The analyzer was invaluable for both the day to day use as a production tool and for quantitative analysis of experimental equipment. The unit has a good graphic display and readily shows improvements made by adjustments as well as when those adjustments are becoming detrimental to the signal.

With the signal processing still switched out the pre-amplifier's (PS Audio model PS IV) turnover point and response curve in the phono section is selected. At this point the first signal processor (Packburn model 323 noise suppressor) is switched into the chain. After adjusting the input level the low pass filter is adjusted. The filter can be used at either a variable or fixed frequency and has a selectable rolloff at ten kHz. The filter seems to work better in the fixed mode and is usually set in this mode. The Packburn is especially good at reducing pops and clicks. Since these seem to give many devices problems, the Packburn is almost always placed first in the signal chain. The unit works by switching between the two groove walls and feeding the quieter of the two to the output. The low pass filter helps to some extent with constant high frequency noise.

The next pieces in the signal processing chain are the two Urei model 565 filters. These filters each consist of two tunable high Q notch/peak filters, a high pass and a low pass filter. The notch/peak filters are cascaded and can tune to individual frequencies for multiple adjustments to a particular response curve, or they can both be tuned to identical frequencies for greater effect on a problem area. These filters work well on specific narrow band problems on either discs or tapes. One use is to eliminate unwanted material on the soundtrack. Steady background tones or noises such as air duct noises can be reduced with these filters. In an experiment a production tape with a 50 Hz index tone was run through the two notch filters of one unit.

F. TYPICAL PROCESSING - DISC (cont.)

The index tone was reduced over 50 db with no apparent effect on the voice. Again these results were achieved with the highest Q settings and are less impressive in broadband noise application. The filters are generally bypassed when the material does not call for attenuation of specific frequencies.

The last piece of signal processing gear most commonly used in reclamation of recordings is the DAK model DAK-1 variable frequency noise reduction unit. This piece of equipment along with the Packburn unit are the two most indispensable signal processors for the reclamation work. Although the DAK unit was primarily designed for use on tapes it also works well with discs. The unit works as a floating frequency low pass filter. The sensitivity of the unit is set to the particular material being worked with. The high cutoff frequency varies proportionately with the signal level. As a high level of signal (desired audio) is encountered the cutoff frequency increases, making the filter have less and less effect on the material. As the signal level decreases the cutoff frequency of the filter drops, causing the filter to have a greater and greater effect on the material (filtering the background noise). Of all the variable frequency type of noise reduction processors tested, the DAK was the smoothest operating and produced the most natural sounding results. The unit does have one limitation -- it will give an audible, unnatural increase in noise floor if it detects record pops. The DAK reads the pop or spike as desired signal, opens up its filtering action suddenly and greatly increases the noise level. In most cases this problem can be avoided or at least reduced by using the Packburn ahead of the DAK.

The next piece of gear in the signal chain is the Audio Scope model 3113. It is not a processor but rather an audio analyzer and is used as an evaluation tool. The Audio Scope was used to develop the cleaning process and to research various pieces of equipment. In the day to day reclamation work the Audio Scope is used to choose the stylus best suited to the disc and can give an A/B comparison of the material with and without the signal processors.

Once the material is processed and monitored on the Audio Scope the finished signal is fed to a Sony model 601ESD pulse code modulator and a Panasonic model AG2200 VHS video recorder. The output of the VCR is fed to a Crown model D-150A power amplifier and a pair of JBL model J-325A speakers for playback monitoring.

G. TYPICAL PROCESSING - TAPE

In general, the same procedures detailed above also apply to tape reclamation. Some of the processing equipment used on disc reclamation is the same used on tape reclamation. Revox model PR99 open reel tape decks are used for playback. The signal is fed to the preamplifier but the Packburn is bypassed since its main benefit applies to discs. The two Urei filters generally are used more frequently in tape reclamation where more narrow band problems are encountered. Unwanted steady tones such as whines, air movement in ducts, and some sixty and 120 cycle hums can all be reduced somewhat. The DAK unit is even more effective on tape recordings than on discs. Since tapes do not have pops like disc recordings, the unit can be set for greater sensitivity without producing unnatural background noise shifts.

For some reason, the old "cave sound" (reverb) is more noticeable on tape than disc recordings. Occasionally the ART model 1500 digital delay unit can reduce this effect. This processor digitally stores (in real time) a sample of the audio. The delay of this audio can be manipulated and inverted and fed back into the signal path slightly out of phase. This form of negative feedback partially cancels the reverb signal. This will reduce but not eliminate the reverb in the recording. It was hoped that this process would also be beneficial for print through. However, no measurable success was ever achieved with this.

As with disc reclamation, following the processing equipment is the Audio Scope analyzer. It is used in conjunction with subjective listening comparisons to optimize the effects of processing equipment on the recording. Completing the signal path is the pulse code modulator, the record VCR, power amp, and monitor speakers.

H. PHYSICAL PLAYBACK CONSIDERATIONS - TAPE

Although less common than the physical playback problems of discs, tape does have its own set of physical obstacles to signal retrieval to overcome from time to time. Tapes have become dried out and fragile from years of improper storage. As a result of this deterioration the tapes have a greater tendency to shed and to exhibit a quality known as "bow stringing." This causes a squeal in reproduction from the tape vibrating across the playback head, just as a bow drawn across a violin string. A very light coating of a lightweight lubricant buffed on the playback head will often relieve this problem. This method was easier and yielded better results than trying

H. PHYSICAL PLAYBACK CONSIDERATIONS - TAPE (cont.)

to apply lubricants to the tapes themselves. Care should be taken not to apply the lubricant too heavily as this can cause the heads to become clogged more easily with oxide from a tape with shedding problems.

When dealing with a tape that has shedding problems, efforts should be redoubled regarding tape handling and machine maintenance. Rapid shuttling of the tape should be avoided since many tapes have loose packs and will slip when subjected to quick changes in direction. If a loose tape pack is encountered it is a good idea to re-pack the tape by playing the tape before any reclamation efforts. Machine tensions, tape guides, and the tape path in general should be examined often. Any worn parts should be given attention immediately. Of special importance in this area are the tape heads. Any worn areas can worsen tape shedding and, since the tapes will have a greater tendency to shed anyway, remembering to clean the heads is of utmost importance.

A final area of tape deterioration to be addressed is print through. No electronic processing means was ever discovered in the research efforts of this project to reduce print through, but a somewhat risky physical method was experimented with. Print through is an unwanted transfer of the magnetic signal from one layer of tape to the next. The field strength of this unwanted signal is substantially less than the desired signal's field strength. If the tape is subjected to a weak outside magnetic field the weaker unwanted signal will be erased before the stronger signal. This is accomplished by holding a permanent magnet in close proximity to the tape as it is being played. The strength of the field the tape is subjected to is controlled by varying the distance between the magnet and the tape. It can be very tricky getting this distance correct -- if the magnet is brought too close the soundtrack itself can be accidentally erased. This is a serious problem because this procedure only works on the original master. If the tape is copied, the unwanted printed signal is copied with the same field strength as the desired soundtrack. The degree of improvement achieved with this method is directly related to the amount of difference in the strengths of the two signals' fields. Since the two signals' field strengths are identical on the copy no improvement can be achieved without also destroying the desired soundtrack on the copy.

I. CURRENT PHILOSOPHY OF PROCESSING

By now it should be apparent that the reclamation process is one of compromise and striking a balance. Once an initial rough set up is established for a particular record or tape it is wise to go back through the processing chain to fine tune the different pieces of equipment so they complement each other's operation. For instance, when processing a record it is best to place the Packburn first to remove the pops and clicks so they don't interfere with the DAK's operation. However, since the DAK is so well suited to reducing high frequency noise it makes the most sense to rely less on the Packburn's low pass filter (which is more primitive) and let the DAK do most of the work in this area.

Even with the most judicious use of the most sophisticated equipment available some situations arise where compromising is necessary. In the research conducted it was found that most types of noise could be reduced or eliminated. The catch is to remove as much noise as possible without introducing serious distortion in the desired recorded material. By using both the Audio Scope for quantitative observations and human judgement in subjective audible comparisons the most beneficial use of the equipment is made. Throughout this portion of the project the emphasis has always been on preserving as much as possible the original character of the voice while creating a listenable, rather than pristine, soundtrack.

J. SPECIFIC EXAMPLES - DEMOS

As techniques of reclamation progressed, short demonstration tapes were sent to NLS periodically for evaluation and comments. Some of the first demo tapes sent showed improvements in overall signal to noise ratio of from two to ten db. These first tapes involved the use of the controls in the phono preamplifier section, use of the Packburn, limited filtering, and selection of stylus from a limited pool of replacement styli. After finalizing the cleaning/lubricating process and equipment purchases two complete titles were chosen to process. AFB title 61-762, "A Burnt Out Case" by Graham Greene, read by Alexander Scourby; and APH title 33711, "Quest of the Snow Leopard" by Roy C. Andrews, read by William Gladden, were processed and digitally stored.

"Quest of the Snow Leopard" had been worked with extensively throughout the project. The first attempts to reclaim this title yielded improvements of between two and three db in the signal to noise ratio. This latest processing of the title improved the signal to noise ratio fourteen db.

J. SPECIFIC EXAMPLES - DEMOS (cont.)

(NOTE: All figures quoted are the improvements achieved AFTER disc cleaning, lubrication, and stylus selection. The actual improvement in noise levels from the discs' "off of shelf" condition is slightly greater.)

The second title, "A Burnt Out Case," was processed and an improvement of 6.5 db in the signal to noise ratio was achieved. This title had not been processed before in the development phase of the project but was chosen for processing as a complete title due to its length (16 sides versus over 100 for the other two sample titles used in demo tapes).

The two titles (32 sides total) were processed and stored in the digital video tape medium used for archival storage. Next, the digital video tapes were transferred to 1/4 inch open reel format. On August 22, 1989 the open reel copies of the two complete titles were sent to the head of the Materials Development Section at NLS for review and comments. APH currently awaits any critiques that NLS has of this material.

K. COSTS

To put the reclamation process into perspective as a viable program for NLS it may be beneficial to discuss it from a dollars and cents approach. The labor costs for reclaiming material are composed of two main operations: the set-up, and the transfer time. While the set-up of each disc is unique, once an operator is familiar with the rack processors' operation it should be possible to set-up most discs within ten to fifteen minutes. This time is in addition to the fifteen to twenty minutes required for the ultrasonic cleaning bath. The second labor cost for processing material is the actual transfer time. This will vary from disc to disc. The cost per minute to process is inversely proportional to the time recorded on that disc. A fifteen minute disc would take fifty minutes (35 minutes to clean and set-up and fifteen minutes to transfer) to process. This works out to a cost of \$1.35 per minute of reclaimed material. A thirty minute disc would take 65 minutes to process (35 minutes to clean and set-up and thirty minutes to transfer) at a cost of 87 cents per minute of reclaimed material.

The tapes to be reclaimed should typically cost less per minute than discs. The tapes are not ultrasonically cleaned like discs. Normally, (unless the tape is dry and causes bow stringing) the only set up is to adjust the actual processing equipment. This means that the time required to process this material is largely the actual transfer time, resulting in a lower cost per minute.

IV. SONIC ENHANCEMENTS AND RECLAMATION OF OLDER RECORDINGS pg 16
(cont.)

K. COSTS (cont.)

Even using the more expensive disc processing figures, these costs compare favorably when compared with the current cost per minute (\$3.00 +) of recording. This does not take into consideration the added benefit of preserving a classic reader or a gifted rendition of an author's work.

(NOTE: The above figures are averages and should be taken as approximations and not absolutes. Certain individual titles may present special problems and need to be specially evaluated to decide if reclamation is prudent.)

SECTION V:
THE FUTURE AND CONCLUSIONS

A. INTRODUCTION

When the digital project was assigned there were three main areas of interest: archival, production applications, and reclamation of old recordings. The project presented rather unique challenges because methods and applications for new technology were being formulated while the technology was developing and changing. Several times during the project directions had to be changed when a method or piece of equipment did not perform as expected or became discontinued. Perhaps one of the biggest disappointments of the project was the unavailability of the Finial Laser Turntable. Beginning in 1986, repeated attempts were made to contact Finial Technologies regarding the development of their turntable. After being told numerous times that it was "just around the corner" it was decided to use a standard turntable for playback in the reclamation section of the project. In February of this year Finial made the announcement in a press release that the laser turntable was no longer a viable product and would be dropped.

Still another example of the volatility of digital technology is that Micro-Signal, a company that was investigated for out-of-house software signal processing, is now out of business. The project staff has been fortunate in correctly assessing industry trends (e.g., choosing VHS over Beta format for archival tape) when making equipment and directional decisions for the project.

B. ARCHIVAL

The archival portion of the project utilizes the methods and materials currently the best suited to this application. However, since the tapes are stored on magnetic tape (even though stored digitally) they do have a shelf life. The shelf life is greatly extended over that of analogue magnetic tape but it will deteriorate eventually. One medium that may be worth considering is an optical disc WORM (write once read many) system. This would also make the archives less maintenance oriented, perhaps eliminating the need for stringent climate control and machine maintenance. The problem with WORM is that it is still in its infancy and probably won't be commonly available for several years.

One of the things the National Library Services should be most concerned with is not the actual physical methods of archival storage but rather the methods for selecting the current recordings to be archived and allotting storage for the growth of the archives. Criteria need to be developed

B. ARCHIVAL (cont.)

by NLS and the various producers as to what constitutes a recording worthy of archival storage, thus establishing a starting point for a systematic plan for archival development. An ongoing archival program could then be established. In support of this concept consider this fact: In the year 2025 the books that were in progress at the start of this project will be as old, (and possibly as historically significant) as the titles currently in the reclamation portion of this project. Consider the difference in quality that would be possible today if the recordings from 1940 had been uncirculated, archived copies. Regardless of the recording technology used, reclamation is substantially easier when working with undamaged, properly archived copies.

C. PRODUCTION / TALKING BOOK PROGRAM APPLICATIONS

C1. INTRODUCTION

Much earlier in the report it was stated that unless a recording is distributed in digital format digital recording as a production tool is not worthwhile. This is not to say that digital recording is useless. It simply means that it is not useful to the NLS program in its present form. It does not make good fiscal or common sense to go to the expense and effort to record digitally only to lose ninety per cent of the improvements in the subsequent analogue production steps. However, if those production steps were digital, the end user would see all of the improved quality and benefits of digital technology. Assuming this was so the next step would be choosing a user format.

C. PRODUCTION / TALKING BOOK PROGRAM APPLICATIONS

C2. DIGITAL TAPE

There are two basic directions to go in the area of user format: digital tape and optically read digital disc (CD). Both mediums are above reproach in their levels of quality. The choice is one of convenience of use (portability, access speed, etc.) and durability. Digital tape has several shortcomings in these areas. It is still a tape format so it is still subject to physical damage from the player or from abuse. This is not a problem in a highly controlled archival setting but in real world use tapes can take a beating. The video tapes used in archival work are bulky, which would make a format called RDAT the choice for portability. Unfortunately, RDAT has its own drawbacks. RDAT has been on the

C. PRODUCTION / TALKING BOOK PROGRAM APPLICATIONS
C2. DIGITAL TAPE (cont.)

drawing board for some time now. It has been the subject of a lot of turmoil and has had numerous delays in its introduction. The format has had an uphill battle for acceptance and hardware is still only available on a professional level. It is very likely that RDAT will not be around in a few years (much like the fate of Beta format video tape). Finally, RDAT or any tape format will not take full advantage of a very nice user feature of digital -- rapid access to material. Digital tape with a time code track can give you very accurate access to material but it is still fast forwarding a tape. This is not much faster than the index tone method currently in use.

C. PRODUCTION / TALKING BOOK PROGRAM APPLICATIONS
C3. COMPACT DISCS

The medium that would truly take full advantage of a digitally recorded title is an optically read digital disc. Since the disc is read with a laser there is much less chance of the machine damaging the disc. There are no rollers, guides, or pickup devices that clog with oxide and mishandle the recorded medium. There is no wear from playback because there is nothing actually touching the disc's playback area. The discs, though not indestructible, will withstand a remarkable amount of abuse.

The technology for digital, or compact, discs (CDs) is also already accepted. The playback hardware is widely available on the consumer level and the medium itself is already firmly entrenched in the marketplace. Although CDs are developing different varieties of options, the basic compact disc should enjoy a very long life and should not be in danger of becoming obsolete if adopted for use in the NLS Talking Book program.

The access time for data retrieval on CDs is many times faster than any tape format. Any point on the disc is accessible in from one to three seconds. Chapters, headings, or even pages of a book could be marked in the time code of the disc. This would enable you to locate any page of a book in just seconds at the touch of a few keys.

CDs are also not without some faults. They are limited in the amount of material that can be put on a disc and they are comparatively expensive to produce. The time constraint of a compact disc currently is 150 minutes per disc: 75 minutes x 2 independent channels. It may be possible to double this to 300 minutes by using both sides of the disc (currently CDs are only recorded on one side). Whether or not

C. PRODUCTION / TALKING BOOK PROGRAM APPLICATIONS

C3. COMPACT DISCS (cont.)

current manufacturing methods are reliable enough to produce two-sided CDs would need to be investigated, as would a method of labeling. Another form of disc, CD Interactive would be able to get around this time constraint through longer individual soundtracks but it is not as established as CD ROM.

C. PRODUCTION / TALKING BOOK PROGRAM APPLICATIONS

C4. COSTS

The expense of CDs is a matter of weighing the benefits against the costs and making a decision. During the project quotes were obtained on the costs of a production run of a typical talking book: nine sides (792 minutes) per copy and a run of 1000 copies. This translates to six compact discs using standard formats. The run would cost \$29,550 verses \$1,000 for a standard run of cassettes. The run cost will decrease to \$23,775 if a two sided CD is viable. These figures are based on quotes from early in 1987. (See Progress Report Number Nine - March 1987.) The costs have come down since then because factory capacity is catching up with demand and mastering costs have declined. Part of the cost could be recouped by pulling a few copies directly from production and using them as archive copies, saving the cost of archival and having an even more permanent, compact storage medium as well.

Two other methods of cost reduction also deserve consideration. The first is CDI. With CDI it is possible to reduce the sampling rate to gain storage capacity (time) on a disc. CD ROM uses a standard sampling rate of 44.1 kHz to yield a frequency response flat to more than 20 kHz. Since the talking book deals almost strictly with voice the sampling rate could conceivably be lowered to 12 kHz without seriously affecting the voice quality. Some work has been done in this area and as much as nineteen hours of audio has been stored on one disc. This would be the equivalent of getting a thirteen side book on one disc. Although no firm figures on production costs are available the quotes used in the above paragraph can be used as a rough guide for comparison. A standard talking book (792 minutes @1000 copies) could be produced for \$4,925. A thirteen sided book could actually cost about the same to produce on CDI as on cassettes using these figures.

The drawback to CDI is that it takes a CDI player to retrieve the signal due to the special parameters each disc has. The CD player must interact with the medium. The players are not widely available yet and the use of standard consumer CD players in the program for cost savings is precluded. Since

C. PRODUCTION / TALKING BOOK PROGRAM APPLICATIONS

C4. COSTS (cont.)

the medium is still evolving, it is not recommended that CDI be used at this time for the Talking Book program. This is a medium that bears watching for possible use in the future.

The second method of cost reduction would be to use CD technology in a limited manner in the talking book program. Instead of producing runs of all types of books, limited runs of reference materials (encyclopedias, thesauruses, biographical, dictionaries, etc.) could be made and distributed to the library centers. People could come and use these references at the library instead of checking them out. This would limit the size of the runs and the books would be larger. Larger books tend to approach the cost of cassette copies. The smaller quantities would cause the per copy cost to increase but the total cost of the run would be reduced.

Weighed against this admittedly high cost is a great deal of user friendliness and satisfaction offered by the medium. The discs are easy to use, provide rapid access, and have a sound quality that is phenomenal. If the general consumer market response can be taken as an example it is safe to believe that CD ROM would be greeted very enthusiastically if it were introduced into the Talking Book program. It is also safe to assume that the demand for government furnished players for discs would not be as high as for tapes (if the sampling rate were kept standard) since a portion of the blind already have consumer CD players. It is interesting to note that an independent study was conducted to evaluate the various digital methods of recording for the Royal National Institute for the Blind about two years after the start of the National Library's digital project. The purpose of the study was to determine if the new recording technology could be instrumental in updating and giving new direction to the RNIB program. The RNIB report concluded, as does this body of research, that of all of the media studied compact discs offered the most benefits and promise. The RNIB report is discussed more thoroughly in Progress Report Number Nine (3-87).

D. ENHANCEMENT AND RESTORATION

The enhancement and restoration portion of the project also involves the same choices as the production applications of the project: money verses benefit. Many approaches (especially software processing) are very good at correcting problem soundtracks. The tradeoff again is expense; expense in startup and equipment costs; expense in trained personnel; and expense in lengthy processing times. By sacrificing a small amount of

D. ENHANCEMENT AND RESTORATION (cont.)

effectiveness the reclamation process becomes less expensive and more viable in operating logistics.

The methods and equipment for reclamation have been thoroughly researched and tested. Like all aspects of the digital project new equipment is being developed constantly and the industry should be monitored for possible developments applicable to the project. However, a working process for reclamation is currently in existence and would probably only be refined and not revolutionized by developments. The most pressing need of the reclamation project is in the area of specifications.

The process can make real improvements in material but there are limitations. There is no "magic box" that will take a 1940's record that has been damaged and physically abused and make it sound like a well made recording produced with 1989 technology. This means if 1989 NLS specifications are applied to the reclaimed titles most would be deemed sub-standard. Yet all of the material worked with has some historic significance. A decision must be made weighing the value of the material against the uncorrectable flaws in the material. This decision requires guidelines for both the selection of the material to be reclaimed and at what point the material is too inferior to be enjoyable even after clean up. How do you weigh the value of an Alexander Scourby or a Livingston Gilbert narration against its technical limitations ?

A survey of talking book users would almost certainly show a strong interest in hearing this material again even with some technical shortcomings. If the material was re-released it could have a message recorded at the beginning of the book stating that the recording was older, reclaimed material and that the soundtrack might have some technical flaws. It is strongly recommended that NLS and the project participants meet and develop these criteria before producing significant amounts of reclaimed titles.

E. CLOSING REMARKS

The purpose of this project was to research the equipment and methods of digital recording, develop archival and reclamation processes, and research possible applications of digital technology to the Talking Book program. This report attempts to highlight those efforts of research and development and to discuss some of the new directions in which digital technology can take the Talking Book program in the future. This section in particular offers many suggestions for the application of the

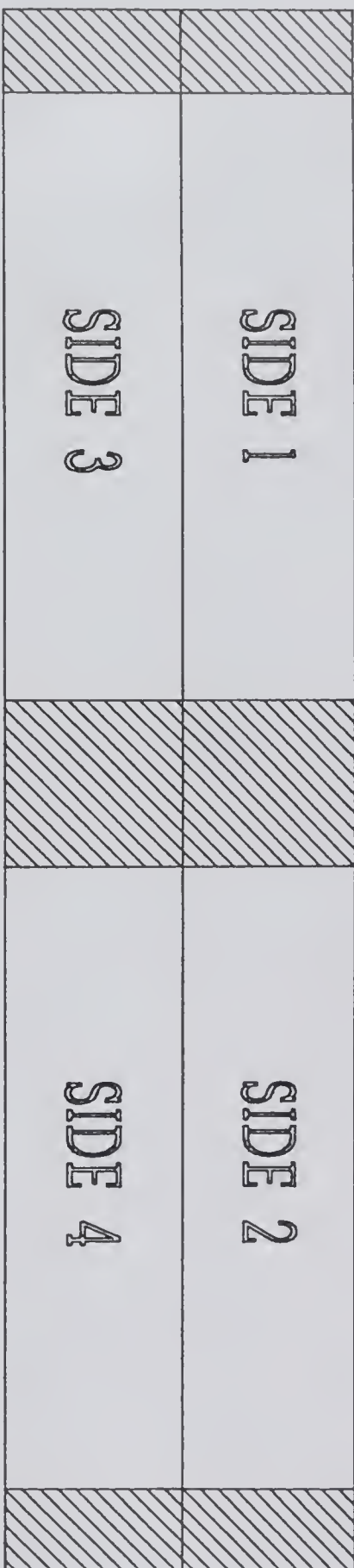
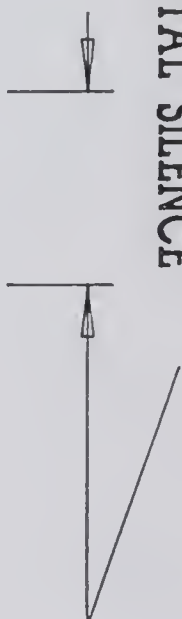
E. CLOSING REMARKS (cont.)

knowledge gathered these past four years to the NLS program.

The recommendations given in this report are just that: suggestions, or "food for thought." The digital technology available today could be tremendously beneficial to the Talking Book program. Admittedly, to fully realize these benefits would require extensive dollars and changes in the Talking Book program. There are no delusions that these changes could or even should happen overnight or that any suggestion would be adopted in its present form. Such far reaching decisions require the National Library Service to sort its options carefully and take the time to formulate standards and a coherent plan to incorporate digital technology into the Talking Book program. It is hoped that the Library will review the information contained in this final report and the preceding fifteen progress reports on the digital project and use that information to decide how (or even if) digital recording technology will be used to improve the Talking Book program.

APPENDIX A

2 MINUTE RECORDED DIGITAL SILENCE



LEFT RIGHT

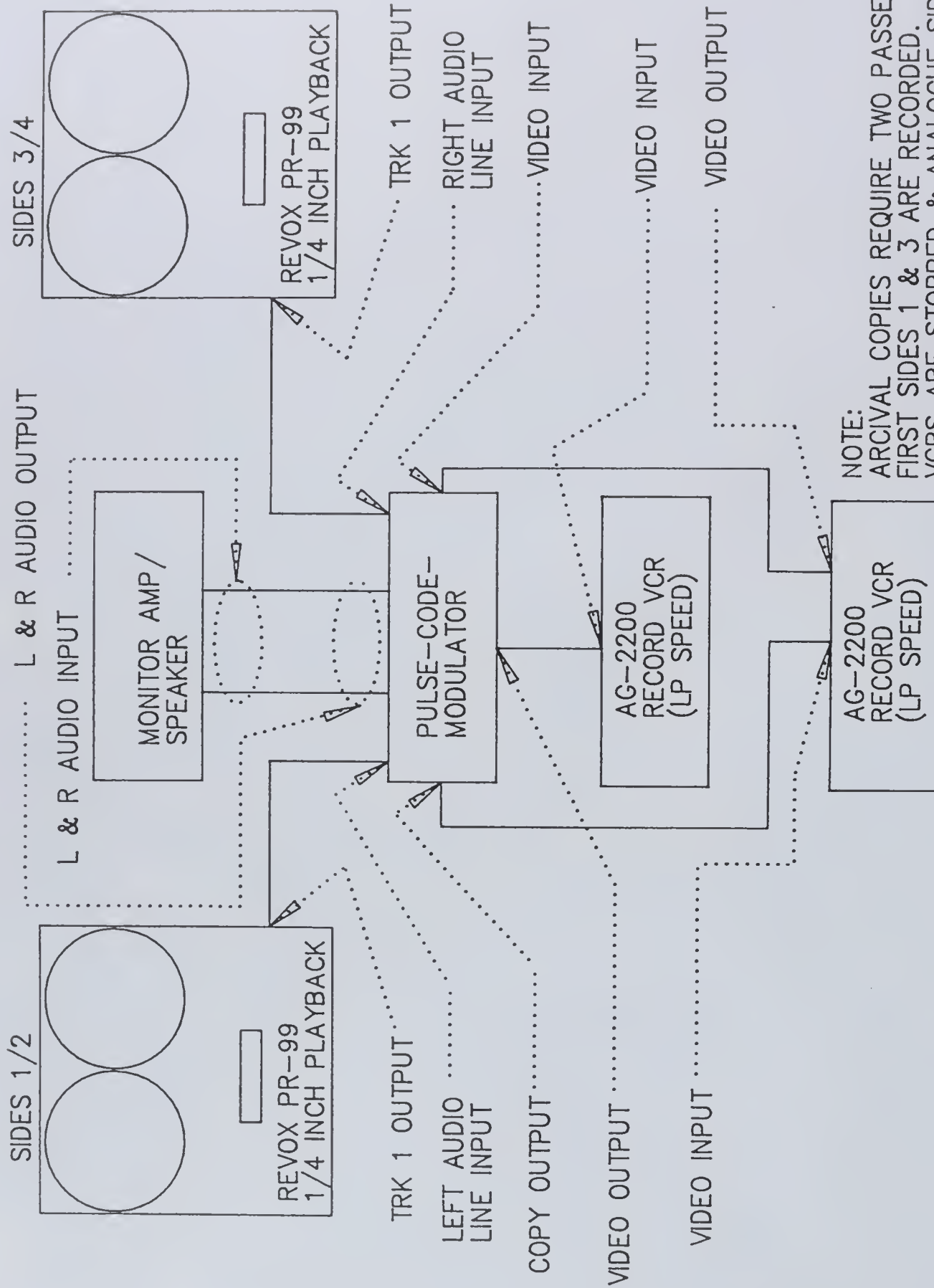
88 MINUTES

88 MINUTES

1 MINUTE RECORDED DIGITAL SILENCE

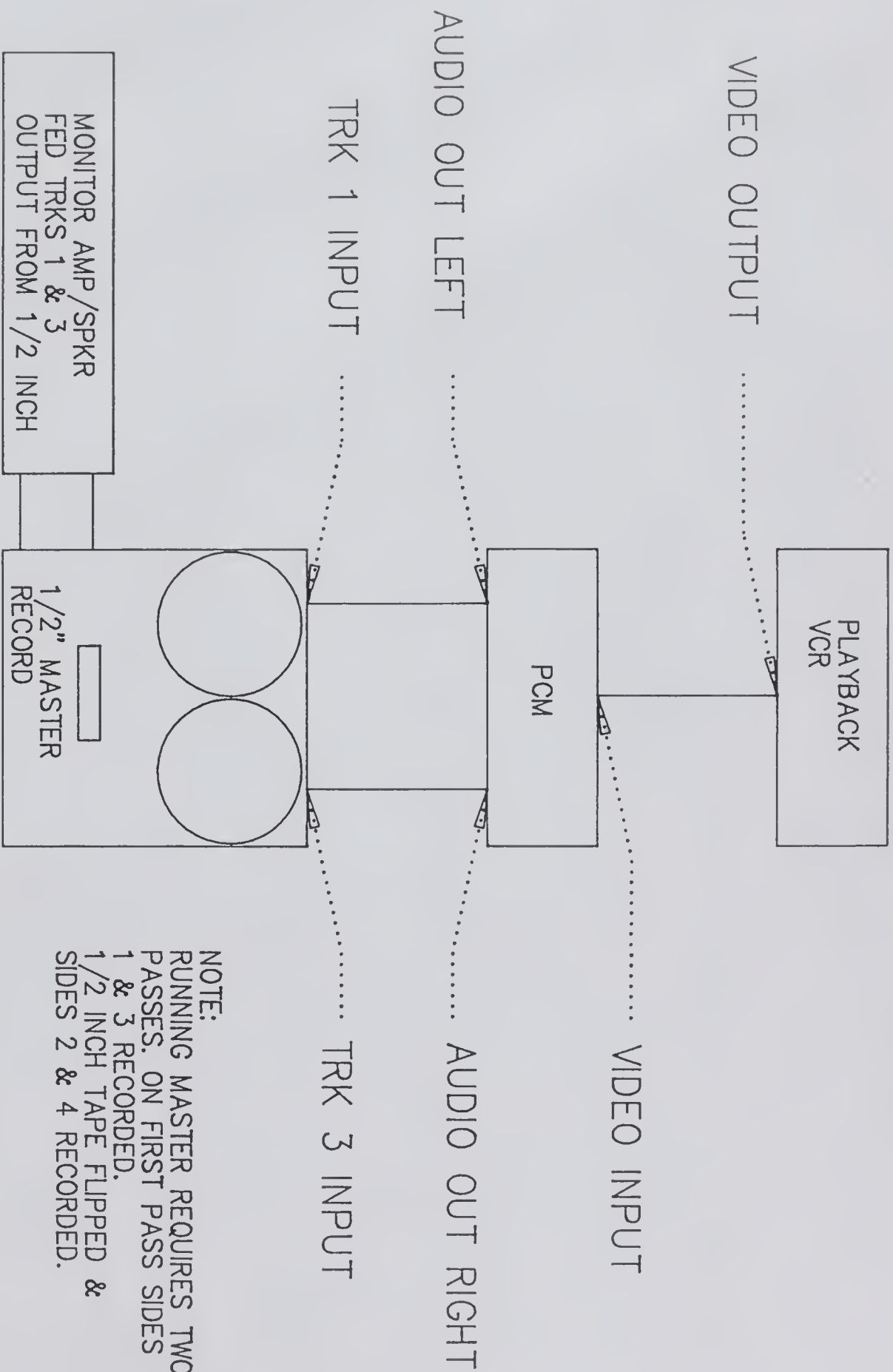
180 MINUTES TOTAL
(T-90 RECORDED LP)

ARCHIVAL TAPE STORAGE FORMAT



NOTE:
 ARCIVAL COPIES REQUIRE TWO PASSES.
 FIRST SIDES 1 & 3 ARE RECORDED.
 VCRS ARE STOPPED & ANALOGUE SIDES
 2 & 4 ARE RECORDED.
 TWO VHS ARCIVAL COPIES ARE
 PRODUCED SIMULTANEOUSLY.

TRANSCRIPTION SETUP FOR ARCHIVAL COPY PRODUCTION



NOTE:
 RUNNING MASTER REQUIRES TWO
 PASSES. ON FIRST PASS SIDES
 1 & 3 RECORDED.
 1/2 INCH TAPE FLIPPED &
 SIDES 2 & 4 RECORDED.

ARCHIVAL COPY RETRIEVAL FOR MASTERING

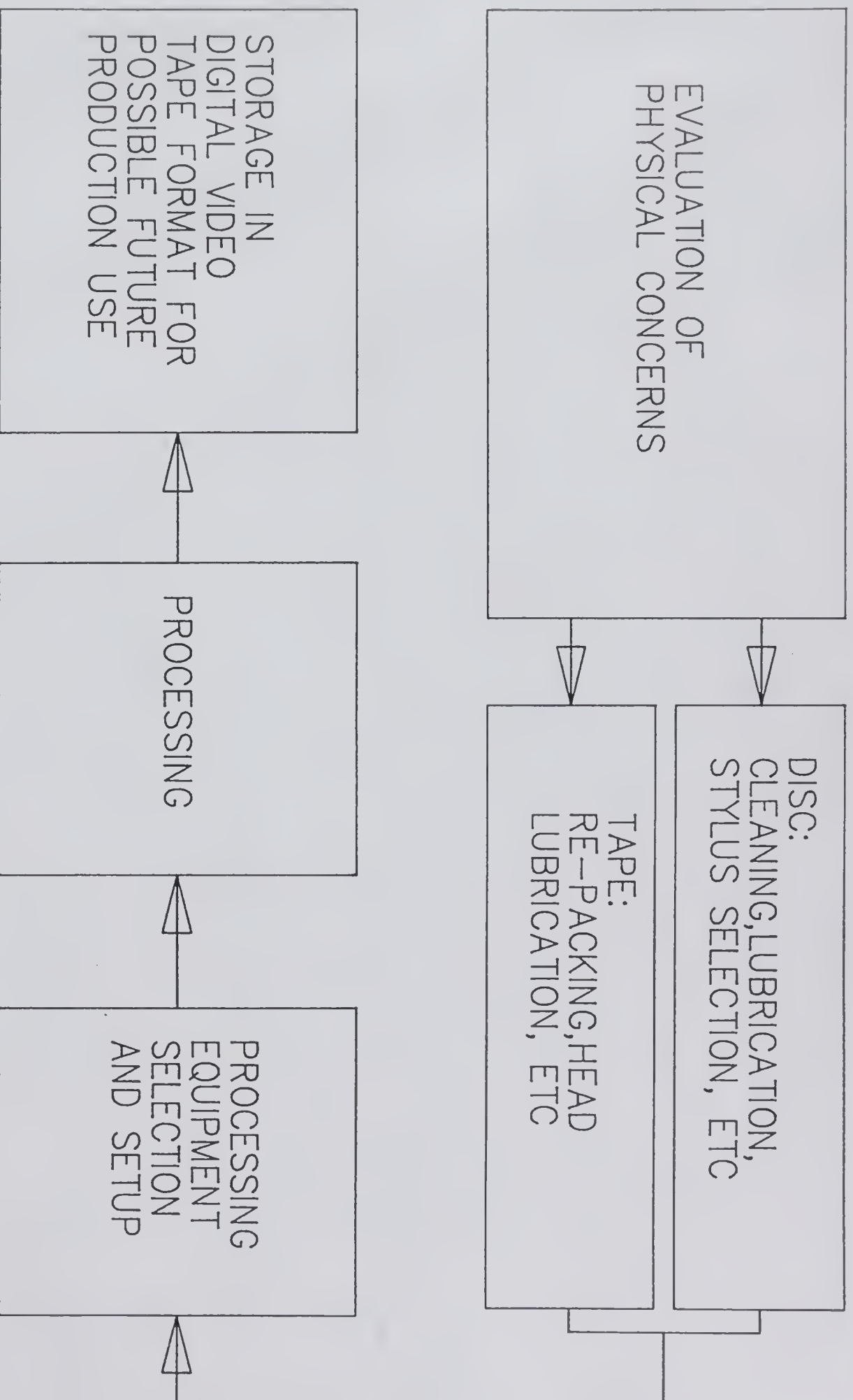
RC #	TITLE	SIDES	VID CAS	BIN	SHELF	TRANS BY
23282	CHEAPER BY THE DOZEN	5	2	A	1	APH
23301	MR PEPPER'S PENGUINS	2	1	A	1	AFB
23323	THE IDIOT	18	5	A	1	AFB
23325	ASK ANOTHER QUESTION	2	1	A	2	AFB
23326	S.O.R. LOSERS	2	1	A	3	AFB
23334	PROFESSOR & EMMA	8	2	A	2	AFB
23335	MID-SUMMER NIGHT'S...	3	1	A	4	AFB
23342	RISE & FALL OF 3RD...	41	11	D	1	AFB
23346	JUSTICE AT WAR	12	3	A	1	AFB
23349	SPIRIT OF AMER. PHIL	6	2	A	3	APH
23368	ADAM BEDE	16	4	A	1	AFB
23370	HIROSHIMA MAIDENS	6	2	A	4	AFB
23371	WORLD OF ANCIENT...	6	2	A	5	AFB
23403	CASTING OF BELLS	1	1	A	5	AFB
23406	DANGEROUS SUMMER	5	2	B	1	AFB
23411	SEEDS OF REVOLT	12	3	A	2	AFB
23412	YEARS OF ORDEAL	11	3	A	3	AFB
23414	MAIGRET AFRAID	4	1	B	1	AFB
23415	SILAS MARNER	6	2	B	2	AFB
23420	ARAB WORLD	13	4	A	2	AFB
23658	FROM THE FAIR	9	3	A	4	AFB
23691	ORLANDO	7	2	B	3	AFB
23694	MEMORIES, DREAMS, ...	9	3	A	5	AFB
23696	HENRY VIII	13	4	A	3	AFB
23699	GATHERING STORM	20	5	A	2	AFB
23700	THEIR FINEST HOUR	19	5	A	3	AFB
23701	GRAND ALLIANCE	23	6	E	1	AFB
23702	HINGE OF FATE	25	7	E	1	AFB
23703	CLOSING THE RING	19	5	A	4	AFB
23704	TRIUMPH & TRAGEDY	20	5	A	5	AFB
23725	FERRARO, MY STORY	10	3	B	1	APH
23743	MAKING OF M. TWAIN	9	3	B	2	AFB
23754	MAILER	25	7	E	2	AFB
23759	REMEMBRANCES...VOLI	29	8	C	1	AFB
23760	REMEMBRANCES...VOLII	34	9	E	1	AFB
23761	REMEMBRANCES...VOLIII	31	8	C	2	AFB
23762	PORTABLE JUNG	16	4	A	4	AFB
23808	INDIAN TERRITORY	6	2	B	4	APH
23815	ENDURING HILLS	8	2	B	5	APH
23817	TRUMAN	13	4	A	5	APH
23819	HENRY JAMES	24	6	E	2	APH
23829	STATUE OF LIBERTY	6	2	C	1	AFB
23836	F.D.R.: A BIOGRAPHY	27	7	E	3	AFB
23854	ROBERT FULTON	12	3	B	3	APH
23862	VITAMIN C	5	2	C	2	AFB
23876	MAN & HIS SYMBOLS	10	3	B	4	AFB
24226	INMAN DIARY: VOL I	34	9	E	2	AFB
24227	INMAN DIARY: VOL II	33	9	E	3	AFB
24229	ISADORA	11	3	B	5	AFB
24240	CHRISTOPHER COLUMBUS	9	3	C	1	AFB
24244	OUR THREE SELVES	13	4	B	1	AFB
24245	BULL HALSEY	12	3	C	2	AFB
24285	TRAGEDY OF HAMLET	4	1	B	2	AFB
24290	DON QUIXOTE	27	7	E	4	AFB
24292	DOLL HOUSE	3	1	B	3	AFB
24293	MACBETH	3	1	B	4	AFB
24311	PORTABLE MILTON	17	5	B	1	AFB
24312	OLD CURIOSITY SHOP	20	5	B	2	AFB
24328	MAN FOR ALL SEASONS	3	1	B	5	AFB

RC #	TITLE	SIDES	VID	CAS	BIN	SHELF	TRANS BY
24327	BETWEEN THE ACTS	5		2	C	3	AFB
24363	OF HUMAN BONDAGE	18		5	B	3	AFB
24433	FABELS OF AESOP	2		1	C	1	AFB
24449	LITTLE WIZARD...02	1		1	C	2	AFB
24660	MURROW:HIS LIFE...	24		6	E	3	AFB
24747	FARMER IN THE SKY	5		2	C	4	APH
24801	NAT'L ARCH....U.S.	5		2	C	5	APH
24810	COOKING W FRAG. HAND	5		2	D	1	APH
24815	HARRIET THE SPY	5		2	D	2	APH
24820	LANTERN IN HER HAND	7		2	D	3	APH
24824	RIDING FOR THE BRAND	7		2	D	4	APH
24826	THE HORNES	7		2	D	5	APH
24836	RAMONA & HER MOTHER	2		1	C	3	APH
24837	RAMONA THE PEST	2		1	C	4	APH
24839	J OWENS...AN AMER.	8		2	E	1	APH
24866	NEIGHBORHOOD TALES	4		1	C	5	AFB
24870	PARADE'S END	26		7	E	5	AFB
24871	JOHN M KEYNES:VOL I	16		4	B	2	AFB
24875	LOUISE BOGAN	14		4	B	3	AFB
24877	MEMOIRS OF CONFIDANT	12		3	C	3	AFB
24878	MAY DAY	12		3	C	4	AFB
24879	HIST. OF PSYCHOLOGY	18		5	B	4	AFB
24891	SHOOTDOWN	10		3	C	5	AFB
24892	HEMINGWAY:A BIO.	18		5	B	5	AFB
24896	MENGELE	10		3	D	1	AFB
24900	STORIES OF H. BOLL	22		6	E	4	AFB
24919	AUTOBIO OF HENRY VII	31		8	C	3	AFB
24927	POPE JOHN	18		5	C	1	AFB
24939	BECK:A BOOK	4		1	D	1	AFB
24959	I KNOW WHY THE CAGED	7		2	E	2	APH
24963	GENERATION OF VIPERS	11		3	D	2	APH
24966	EISENHOWER...1943-45	30		8	C	4	APH
24972	BEST MYSTERIES	10		3	D	3	APH
24973	MARGRET BOURKE-WHITE	14		4	B	4	APH
24984	MASTERS...SEX &HUMAN	16		4	B	5	APH
24995	HARD TIMES	14		4	C	1	APH
25000	BENSON MURDER CASE	7		2	E	3	APH
25001	MY LIFE IN NO. WOODS	8		2	E	4	APH
25005	ENTREP. OF OLD WEST	10		3	D	4	APH
25007	LIFE OF A. RANSON	13		4	C	2	AFB
25011	REASON IN SOCIETY	4		1	D	2	AFB
25016	O JERUSALEM	18		5	C	2	AFB
25017	H. G. WELLS	19		5	C	3	AFB
25018	GREAT WALL OF CHINA	1		1	D	3	AFB
25022	20TH CENT. PLEASURES	7		2	E	5	AFB
25024	ZORBA THE GREEK	9		3	D	5	AFB
25029	PYGMALION	3		1	D	4	AFB
25030	THE FINDING	3		1	D	5	AFB
25031	LIFE OF WILLA CATHER	8		2	A	1	AFB
25035	EDWARD LONGSHANKS	10		3	E	1	AFB
25036	O - ZONE	16		4	C	3	AFB
25037	BLUE NILE	8		2	A	2	AFB
25040	THIRTEEN FOR LUCK	6		2	A	3	AFB
25041	STORIES...SHAKESPEAR	7		2	A	4	AFB
25042	BLACK WOMEN...@ WORK	8		2	A	5	AFB
25074	HIGH STAND	8		2	B	1	APH
25079	AM. CANCER SOC./BOOK	19		5	C	4	APH
25087	NATIVE SON	12		3	E	2	APH
25094	LUCY:LIFE OF L BALL	7		2	B	2	APH

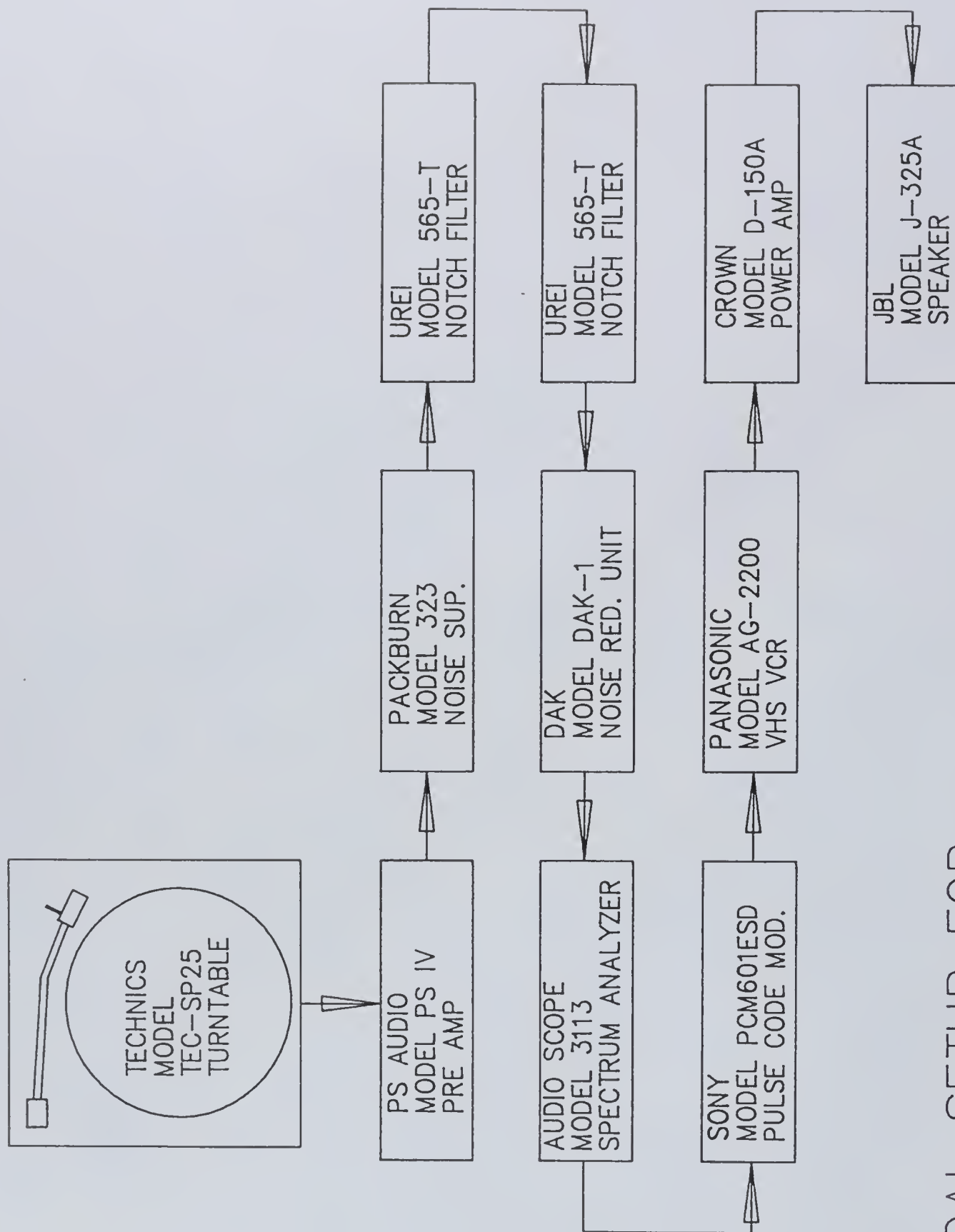
RC #	TITLE	SIDES	VID CAS	BIN SHELF	TRANS BY
25100	DAY KENNEDY WAS SHOT	16	4	C 4	APH
25107	PALE HORSE	5	2	B 3	APH
25111	SWISS FAM. ROBINSON	8	2	B 4	APH
25112	APARTHEID IN CRISIS	7	2	B 5	APH
25118	BEST ROBERT SERVICE	3	1	E 1	APH
25123	OF A FIRE ON MOON	14	4	C 5	APH
25125	BLUEGRASS...A HIST.	18	5	C 5	APH
25141	PARABLE OF THE BLIND	2	1	E 2	AFB
25144	ILLYRIAN ADVENTURE	3	1	E 3	AFB
25147	NO NAME IN THE STS.	4	1	E 3	AFB
25148	A. GARNER'S BOOK	4	1	E 4	AFB
25149	ORDEAL BY INNOCENCE	6	2	C 1	AFB
25155	PEEKHAM'S MARBLES	4	1	E 5	AFB
25158	KIDNAPPED	7	2	C 2	AFB
25161	QB VII	10	3	E 3	AFB
25162	BEETHOVEN	12	3	E 4	AFB
25169	SAYANORA	5	2	C 3	AFB
25170	GABRIELA,CLOVE,& ...	11	3	E 5	AFB
25171	CRUEL SEA	13	4	D 1	AFB
25172	MANCHILD...LAND	12	3	A 1	AFB
25174	ODD COUPLE	2	1	A 1	AFB
25177	COL. STORIES:'48-'86	7	2	C 4	AFB
25178	WUTHERING HEIGHTS	11	3	A 2	AFB
25179	PATH TO ROME	7	2	C 5	AFB
25181	ONE HUNDRED YEARS	10	3	A 3	AFB
25183	MARY, QUEEN OF SCOTS	23	6	E 5	AFB
25186	ARCHITECTURE ANYONE?	7	2	D 1	AFB
25187	MASTERPIECE	9	3	A 4	AFB
25193	MR SANMLER'S PLANET	7	2	D 2	AFB
25197	SAND PEBBLES	14	4	D 2	AFB
25198	EMILY DICKENSON	21	6	D 1	AFB
25204	ROBERT FROST HIMSELF	9	3	A 5	AFB
25209	TEN NO. FREDERICK	12	3	B 1	AFB
25218	WHY SO. LOST CIVIL W	17	5	D 1	APH
25220	VIEW FROM THE STANDS	14	4	D 3	APH
25222	MARTIN L. KING,JR.	2	1	A 2	APH
25228	...DEEP IN CHRISTIAN	13	4	D 4	APH
25232	SHERLOCK HOLMES	4	1	A 3	APH
25237	SHE	9	3	B 2	APH
25240	IMMORTAL WIFE	16	4	D 5	APH
25241	ANDERSONVILLE	26	7	D 1	APH
25244	HOOSIERS... INDIANA	5	2	D 3	APH
25255	ERA OF RECONSTRUCT.	6	2	D 4	APH
25257	MY FATHER MY SON	6	2	D 5	APH
25258	UNKNOWN SOLDIER	7	2	E 1	APH
25259	HARD RIGHT...J HELMS	10	3	B 3	APH
25261	EXODUS	19	5	D 2	APH
25274	TARTUFFE:HYPOCRITE	2	1	A 4	AFB
25281	M MULLITAN...SHOVEL	1	1	A 5	AFB
25282	DOODLE SOUP	1	1	B 1	AFB
25290	SECRET AGENT	7	2	E 2	AFB
25291	DELIVERANCE	6	2	E 3	AFB
25296	SISTER CARRIE	14	4	E 1	AFB
25297	PECOS BILL...	1	1	B 2	AFB
25303	JUNGLE BOOKS	9	3	B 4	AFB
25304	IVANHOE	15	4	E 2	AFB
25305	AFRICANS	9	3	B 5	AFB
25312	YOUNGERMAN GUNS	3	1	B 3	AFB
25316	ENTERTAINERS & ...	7	2	E 4	AFB

RC #	TITLE	SIDES	VID	CAS	BIN	SHELF	TRANS BY
25322	CYCLES OF AM. HIST.	15		4	E	3	AFB
25327	U. S. SENATE	5		2	E	5	APH
25334	DUPONT...AN ADMIRAL	10		3	C	1	APH
25338	HOW CAMEL GOT HIS...	1		1	B	4	APH
25350	ZACHARY TAYLOR	10		3	C	2	APH
25353	MISTY OF CHINCOTEGUE	1		1	B	5	APH
25363	COL. STORIES J WEST	14		4	E	4	APH
25366	MUNCHING...POEMS	1		1	C	1	APH
25370	IMMORTAL WILDERNESS	5		2	A	1	APH
25371	THOSE WHO FALL	9		3	C	3	APH
25382	JO'S BOYS	8		2	A	2	APH
25385	OREGON TRAIL	9		3	C	4	APH
25436	THROUGH GNDPA'S EYES	1		1	C	2	AFB
25437	AN OUTLINE OF PSYCH.	2		1	C	3	AFB
25440	GREEK GENERALS TALK	8		2	A	3	AFB
25442	ON ACTING	6		2	A	4	AFB
25446	ANNE BOLEYN	12		3	C	5	AFB
25456	POWER OF SWORD	23		6	D	2	AFB
25457	FIDEL	21		6	D	3	AFB
25460	GREEK MYTHS	5		2	A	5	AFB
25464	REAL LIFE OF A MAYTA	8		2	B	1	AFB
25467	BEST...NEGRO WRITERS	14		4	E	5	AFB
25468	RELUCTANT EMPRESS	12		3	D	1	AFB
25470	RUMPLE STILTSKIN	1		1	C	4	AFB
25475	HAUNTED BOOKSHOP	5		2	B	2	AFB
25480	FORTUNATE & JACINTA	33		9	E	4	AFB
25482	MOTHER TERESA	1		1	C	5	AFB
25483	SEA SONGS	1		1	D	1	AFB
25485	CLICK!	1		1	D	2	AFB
25486	FANNERY O'CONNER	5		2	B	3	AFB
25489	SCHOOL FOR SCANDAL	4		1	D	3	AFB
25492	KREMLIN & THE WEST	6		2	B	4	AFB
25498	D. FLOR & HER 2 HSBD	14		4	A	1	AFB
25502	SHE STOPS TO CONQUER	3		1	D	4	AFB
25503	JUST SO STORIES	3		1	D	5	AFB
25504	NECTAR IN A SIEVE	5		2	B	5	AFB
25506	VOICE OF PROSE:...	8		2	C	1	AFB
25507	HORNBLOWER & ATROPOS	7		2	C	2	AFB
25509	FREDERICK THE GREAT	21		6	D	4	AFB
25510	PAGANS & CHRISTIANS	24		6	D	5	AFB
25511	VIRTUE PUB. & P'VT	3		1	E	1	APH
25513	ARTISTS OF AM. FOLK	10		3	D	2	APH
25514	DIABETES ASSN. CKBK	5		2	C	3	APH
25517	RIDER OF RUBY HILLS	11		3	D	3	APH
25518	MASTERING MICRO CKRY	18		5	D	3	APH
25519	WRITTINGS	40		10	D	5	APH
25522	ROOTABAGA STORIES	4		1	E	2	APH
25525	READY, SET, READ	10		3	D	4	APH
25529	FAVORITE FOLKTALES	12		3	D	5	APH
25537	ELEANORE...YRS ALONE	10		3	E	1	APH
25546	ON CAMERA...	6		2	C	4	APH
25547	INCREDIBLE SIXTIES	7		2	C	5	APH
25554	VICTORIA...INT. BIO.	23		6	C	1	APH
25556	MY FIVE SENSES	1		1	E	3	APH
25564	ENGAGED TO MURDER	7		2	D	1	APH
25567	PRES.'S HOUSE	19		5	D	4	APH
25568	PRES.'S HOUSE VOL II	15		4	A	2	APH
25573	MKING OF JOURNALIST	7		2	D	2	APH
25574	MOTHERS OF FEMINISM	7		2	D	3	APH

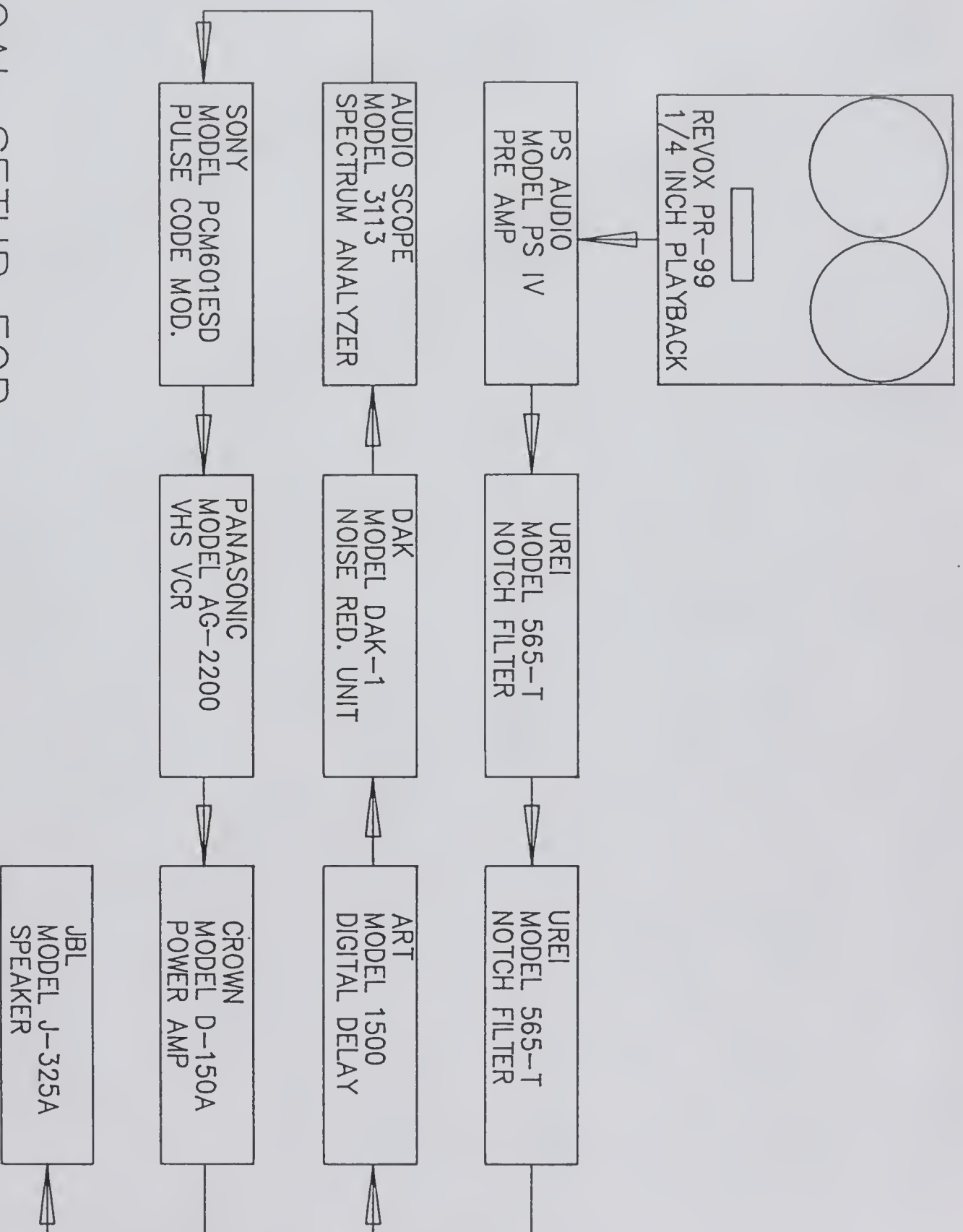
RC #	TITLE	SIDES	VID	CAS	BIN	SHELF	TRANS BY
25576	A C CLARKE'S JULY 20	8		2	D	4	AFH
25577	MADE IN THE U.S.A.	9		3	E	2	AFH
25581	AMER. CONSTITUTION	31		8	C	5	AFH
25586	WE HOLD THESE TRUTHS	7		2	D	5	AFH
25587	NEW ORLEANS LEGACY	12		3	E	3	AFH
25599	STILLMEADOW SAMPLER	7		2	E	1	AFB
25600	STILLMEADOW DAYBOOK	7		2	E	2	AFB
25601	SELECTED POETRY	15		4	A	3	AFB
25604	MANHATTAN CHILI...	3		1	E	4	AFB
25609	DARK VICTORY	10		3	E	4	AFB
25610	SEL. STORIES O'HARA	9		3	E	5	AFB
25611	PAPILLION	13		4	A	4	AFB
25612	KRISHNAMURI:A BIO.	17		5	D	5	AFB
25613	COL. STORIES VOL 2I	13		4	A	5	AFB
25614	COL. STORIES VOL 3	7		2	E	3	AFB
25618	BEST OF SAKI	6		2	E	4	AFB
25620	OLD DEVILS	9		3	A	1	AFB
25622	MARCELLA'S IT. KIT.	12		3	A	2	AFB
25626	MAKING OF ATOM BOMB	28		7	D	2	AFB
25632	SCHUBERT & HIS ...	7		2	E	5	AFB
25635	NUNCA MAS	14		4	B	1	AFB
25636	CROSSING THE LINE	12		3	A	3	AFB
25637	DOSTOEVSKY:1860-1865	14		4	B	2	AFB
25640	READ-ALOUD RHYMES...	1		1	E	5	AFB
25641	REASON IN ART	5		2	A	1	AFB
25642	MARTIN BUBER...	4		1	A	1	AFB
25647	USES OF LIT.:ESSAYS	7		2	A	2	AFB
26426	UP WITH HOPE	3		1	B	2	AFB
26427	DR. JECKYLL...	3		1	B	3	AFB
26428	THE MIRACLE WORKER	2		1	C	5	AFB
26429	MIAMI	4		1	B	2	AFB
26430	THE CASUALTY	4		1	C	1	AFB
26431	IMPORTANCE OF BEING	8		2	C	1	AFB
26434	COMEBACK:	7		2	E	1	AFB
26435	APARTHEID	8		2	C	1	AFB
26438	THE RAT	11		3	D	1	AFB
26439	THE ULTIMATE EVIL:	17		5	A	5	AFB
26441	THE CULT MOVEMENT	3		1	B	4	AFB
26443	COMEDY OF ERRORS	4		1	E	1	AFB
26445	DOROTHY DAY	5		2	B	4	AFB
26446	LOVING LIFE	5		2	C	5	AFB
26449	THOUGHT OF PAUL...	13		4	A	2	AFB
26450	STRUGGLE...EUROPE,...	20		5	C	2	AFB
26458	EGYPT AFTER PHAROHS	8		2	A	2	AFB
26463	ALNILAM	20		5	A	3	AFB
26465	DIGGING TO THE PAST	1		1	A	5	AFB
26474	REX HARRISON	11		3	D	2	AFB
26475	ARCHIBALD MACLEISH	8		2	E	4	AFB
26476	ALEXANDER HAMILTON	12		3	B	5	AFB
26477	THE FAMILY MASHBER	20		5	B	1	AFB
26480	MY FIRST COMMUNION	1		1	E	4	AFB
26481	SECRET LANGUAGE OF..	2		1	A	5	AFB
26486	ULTIMATE GAME	13		4	D	2	AFB
26551	J. HENRY: AMERICAN..	1		1	C	5	AFB



FLOWCHART OF RECLAMATION PROCESS



TYPICAL SETUP FOR RECLAMATION OF DISCS



TYPICAL SETUP FOR RECLAMATION OF TAPES

